3/PRTS 09/646944

534 Rec'd PCT/PTO 22 SEP 2000

Method and apparatus for cutting foils comprising a carrier film and a decorative layer disposed thereon, in particular stamping foils

The invention concerns a method of cutting foils comprising a carrier film and a decorative layer disposed thereon and including at least one lacquer layer, in particular stamping foils and preferably hot-stamping foils, and an apparatus suitable for carrying out such a cutting method, comprising a laser producing a removal laser beam and a cutting blade, wherein both the laser beam and also the cutting blade act at a spacing from each other in the cutting direction on the substrate to be cut.

Stamping or transfer foils, in particular hot-stamping foils, are normally produced in comparatively wide widths and then for processing and packaging cut in the longitudinal direction into strips of correspondingly small width. In order to cut stamping foils, in particular hot-stamping foils, in the direction of travel, round blades and knife blades are usually employed as they are simple and inexpensive to handle. The knife or the blade separate the stamping foil in the cutting operation, giving cut edges which however differ only slightly from a straight line. It is to be noted however that the decorative layer on the carrier film partially chips and flakes off in the cutting operation, whereby the decorative layer on the one hand becomes frayed in the region of the cut edge. On the other hand the material which has chipped or flaked off and which is referred to as cutting powder can contaminate the foil produced and can give rise to problems in the stamping operation.

There would admittedly be the possible option of using suction removal devices or rollers with sticky surfaces, for the purposes of cleaning correspondingly contaminated foils or sheets. In addition it would be possible to use electrostatic discharge devices in order to reduce the electrostatic attraction of cutting powder by the carrier film or the stamping foil. As however the production of stamping foils, in particular

hot-stamping foils, involves operating at processing speeds of 50 m/min and more, and only very little space is available in the production machinery for the installation of additional items of equipment, a procedure of such a nature is only very limitedly possible. In addition cleaning or additional devices of that kind only partially remove the cutting powder.

Furthermore, the conventional cutting technology using knives or blades is observed to involve a considerable amount of blade wear which, with an increasing period of operation, results in an impairment in the quality of the cutting action and in particular the increased occurrence of flaking and chipping.

In principle it would be possible, instead of the mechanical separation operation using knives or cutting blades, to effect subdivision of the corresponding foils by means of laser radiation, in which respect in principle it is possible to achieve very good edge qualities and no chipping or flaking of the decorative layer which is generally formed by lacquer layers occurs. It was found however that, in the attempt to cut hot-stamping foils by means of excimer laser radiation, it was only possible to achieve cutting speeds of about 10 m/min and in addition comparatively high cost levels occur.

Nd:YAG-lasers can be used for cutting hot-stamping foils only when a carrier film which absorbs laser radiation is used. That is not the case with the transparent plastic materials which are usually employed for the carrier film.

CO_2-lasers are hitherto already used on an industrial scale inter alia for cutting plastic curtains and sails. In that respect, the thermal operating principle involved results in fusion of the cut edges, which is wanted in that case. In that procedure, high cutting speeds are possible.

All attempts to cut foils of carrier film and a decorative layer by means of lasers have shown that on the one hand under some circumstances toxic gases and dusts are liberated, which require suitable

suction removal and filtration steps to be taken. In addition attempts to cut hot-stamping foils with a CO_2-laser have shown that a thickening effect occurs at the cut edge due to the fusion phenomenon and the subsequent hardening processes, and that thickened portion, when the cut foil is wound onto a core, results in a bead or ridge at the edge of the roll, which cannot be accepted as on the one hand it prevents a tidy winding effect and on the other hand it possibly causes problems in further processing of a hot-stamping foil.

DE 40 23 997 A1 already discloses a method in which materials which are capable of being cut by a blade are subjected to processing with a mechanical cutting blade, as far as a residual wall thickness. The remainder of the cut is then executed by a laser cutting head. When that method is used for cutting foils or sheets which have on a carrier film a decorative layer which possibly flakes or chips off, then - as hitherto - it would be necessary to reckon on the formation of cutting powder as the decorative layer would be cut with a blade. A procedure in accordance with that proposal can therefore not be considered for cutting corresponding foils.

DE 34 15 015 C2 describes an apparatus for producing a splinter-free cut edge in material in plate or panel form comprising wood, plastic material or the like, having a pre-scratching device and a cutting saw, which are both displaceable relative to the material in plate or panel form. In order to prevent the material in plate or panel form of wood or the like from splintering away at the cut edge in the sawing operation, it is proposed therein that the pre-scratching device includes a laser source for producing a laser beam and a device for focusing the laser beam on the surface of the material in plate or panel form, in order to burn at least one groove of predetermined width and depth into the material in plate or panel form. In that case, the laser beam impinges on the material in plate or panel form somewhat before the edge of the saw blade and the laser cuts are normally made at the location of the material, where the saw

teeth of the cutting saw come out, as is described at column 2, lines 21 to 24. The production of such a splinter-free cut edge in a piece of material in plate or panel form comprising wood, plastic material or the like is not comparable to cutting foils, in particular stamping foils, which comprise a carrier film and a decorative layer which is disposed thereon and which includes at least one lacquer layer.

DE 44 39 220 A1 discloses a method of cutting plastic foils or sheets by means of CO_2-lasers, which is distinguished in that a plurality of mutually superposed webs of a foil or sheet can be cut simultaneously. In order in that case in the cutting operation by means of laser to prevent fusion and thereby sticking of the cut edges of the mutually superposed layers of the foil or sheet, in accordance with the state of the art separating layers, for example layers of paper, are introduced between the individual layers of foil or sheet which are to be cut. A procedure of that kind cannot be implemented for reasons relating to production technology and cost, in the production processing of stamping foils, in particular hot-stamping foils, as a mode of operation of that kind would require in particular multiple winding of the foil to be cut and the cut foil respectively.

Therefore the object of the present invention is to propose a method and an apparatus for cutting foils comprising a carrier film and a decorative layer disposed thereon, in particular stamping foils, preferably hot-stamping foils, in which it is possible to operate at high speeds, a clean cut without flaking or chipping is achieved, and the level of blade wear can be minimised.

In a method of the kind set forth in the opening part of this specification, to attain that object it is proposed that the procedure is such that firstly the decorative layer is removed from the carrier film by means of laser radiation along the cut edge and then in the removal track formed in that way the carrier film is mechanically separated by means of a blade

(in which respect the term "blade" also includes a knife or cutting edge or a roller cutter).

In a procedure in accordance with the invention the lacquer or metallisation layers present in the decorative layer are heated as a result of corresponding absorption of the energy of the laser beam. If now the processing parameters (laser power, spot size, speed of movement of the foil or sheet) are suitably adjusted, then in the region where the laser beam acts on the foil, the material of the decorative layer is removed in a molten or vapour condition and the carrier film is thereby exposed. In that case, a suction removal operation which is operative directly at the processing location can be implemented to ensure that the permissible limit values in regard to pollution and noxious substances at the workplace are observed. The carrier film is then severed by means of a blade in the removal track which has been exposed by removal of the decorative layer. That procedure has the advantage that, as the decorative layer which flakes or chips off has already been removed in the removal layer, no cutting powder of a troublesome nature is now produced in the cutting operation using the blade. The carrier film itself is generally of such a nature that a cutting operation does not result in the formation of a substantial amount of dust or powder. Accordingly, without involving additional expensive cleaning operations, that procedure affords directly in the production operation a foil which has been cut into suitable strips and which is free of cutting powder.

A further advantage of the method according to the invention is that, as only the decorative layer has to be removed by means of laser radiation, comparatively low levels of laser power are already sufficient to remove the layer. This means that either small, relatively inexpensive layers can be used, or very high cutting speeds can be achieved.

A further advantage of using laser radiation for removal of the decorative layer is that no wear of the "cutting device" is to be expected, as regards removal of the decorative layer. For that reason the same

conditions are always involved, that is to say in particular a laser removal track of the same width and configuration whereas hitherto when using blades, considerable variations were to be observed as a result of blade wear here.

Finally the procedure according to the invention also enjoys the advantage that the amount of blade wear can under some circumstances be considerably reduced as the blade only has to sever the carrier film and not the decorative layer which under some circumstances is substantially harder and which in particular is composed of different substances.

In principle it would be sufficient if the width of the removal track formed by laser radiation corresponds to the thickness of the blade cutting the carrier film. If however, as the invention provides, a removal track is formed, whose width is greater than the thickness of the blade cutting the carrier film, in which respect the removal track is preferably of a width of between 1 and 2 mm, it is possible on the one hand to achieve the advantage that it is guaranteed in any event that the blade no longer comes into contact with the decorative layer. On the other hand, any lateral movements of the blade in comparison with the foil to be cut can also be compensated in that way.

It is further provided in accordance with the invention that an Nd:YAG- or diode laser is used for removal of the decorative layer, while in such a case it is possible to use a laser of a power of between 20 and 50 W. The use of an Nd:YAG- or diode laser has in particular the advantage that it does not attack the carrier film which is usually transparent. The comparatively thin decorative layer can be very easily removed with lasers of that kind so that, with the usual widths of the removal track of between 1 and 2 mm, using lasers of that kind, it is possible to operate at working speeds of 70 m/min and more. In addition, when using lasers which do not attack the transparent carrier film, it is also possible for the laser to be arranged on the side of the foil on which

the decorative layer is not present. In that case the decorative layer is irradiated through the carrier film, for removal of the former.

It has proven to be particularly advantageous if the laser used for removal of the decorative layer is a laser which has a laser radiation intensity distribution transversely to the direction of advance of the foil (with respect to the laser), which corresponds to a rectangular (top hat) profile. As a result of the rapid rise and fall of the intensity of the laser radiation when a top hat profile is involved, this provides that initial fusion phenomena, that is to say only transferring the material into the molten condition without complete removal, in the layers of material forming the decorative layer, in the edge region of the foil, are minimised. That affords a particularly clean and tidy edge for the decorative layer. If in contrast operation is implemented with laser radiation which involves a Gaussian intensity profile transversely with respect to the advance direction, then minor amounts of molten material of the decorative layer are thrown up at the edges of the removal track, and that can adversely affect the quality of the decoration produced by means of a corresponding foil and can result in a minor bead or ridge at the edge of the roll.

The invention further provides that the carrier film, subsequent to removal of the decorative layer, is severed by means of the blade at a spacing of less than 70 mm, preferably less than 50 mm, in order in that way to be able to construct an apparatus which is as compact as possible and in which moreover essentially only one processing station has to be observed by the monitoring staff.

A further subject of the invention is an apparatus for carrying out the above-discussed cutting method comprising a laser for producing a removal laser beam and a cutting blade, wherein both the laser beam and also the cutting blade act at a spacing from each other in the cutting direction on the substrate to be cut.

In accordance with the invention an apparatus of that kind is advantageously of such a configuration that the laser and the cutting

blade are of such an arrangement and configuration that in the direction of movement of the foil forming the substrate the cutting blade is arranged adjoining the location of action of the laser beam, wherein the laser beam produces in the decorative layer a removal track which is wider than the thickness of the cutting edge of the cutting blade, which acts on the foil.

The use of an apparatus of that kind makes it possible to achieve a satisfactory, neat severing cut for the foil, in which respect it is reliably guaranteed that only the laser beam acts on the decorative layer in the region where a cut is to be made, so that no cutting powder which is to be attributed to pieces of flaked-off or chipped-off material occurs. The blade which is thin in comparison with the removal track produced by the laser beam can then quickly and neatly sever the carrier film.

If, as the invention further provides, the laser is provided with a device for deflection of the laser beam, positional regulation of the removal track can be effected very quickly by the laser beam being deflected laterally. That can be desirable if, for any reasons, the blade has come out of adjustment, for example because it was bent by virtue of careless handling.

It is further advantageous if the laser has a device for altering the diameter of the laser beam acting on the foil, because then the width of the removal track produced by the laser beam can be easily altered and for example adapted to the wear of a blade.

Desirably, the laser power can be regulated in dependence on the speed of movement of the foil. In that way it is possible for the quality of processing to be kept constant, even when starting up and slowing down the machine and in spite of the speed of movement which generally varies in production machines over the operating length thereof.

By way of example acusto-optical modulators or galvanometers mirrors can be used for lateral deflection of the laser beam. The variation in diameter of the laser beam can be very rapidly effected for example by focus-shifting components, for example adaptive optical systems. In

order to permit the cut to be monitored in a simple fashion, it is advantageous if, as the invention further provides, the spacing between the locations of action of the laser beam on the one hand and the cutting blade on the other hand on the foil is less than 70 mm, preferably less than 50 mm.

Finally it is in accordance with the invention for the laser beam and the cutting blade to be arranged on the same side of the foil to be cut, because that arrangement on the one hand can simplify the construction of the cutting device and on the other hand it can also improve the monitoring options.

Further features, details and advantages of the invention will be apparent from the following description of the method and an only diagrammatically illustrated apparatus, with reference to the accompanying drawing in which:

Figure 1 diagrammatically shows a cutting apparatus having the essential components,

Figure 2 is a diagrammatic view to describe the operation of cutting a hot-stamping foil,

Figure 3 shows the intensity of laser radiation with a so-called top hat profile and the removal track produced with such a profile in a decorative layer, and

Figure 4 shows a Gaussian intensity distribution in respect of laser radiation and the removal track in the decorative layer of a hot-stamping foil, which is produced by a corresponding laser.

For producing for example hot-stamping foils in appropriate sizes, it is necessary for a foil 1 (Figure 1) to be divided into a plurality of narrower strips or bands 1a, 1b. For that purpose the foil 1 which is wound on a supply roll is guided over two direction-changing rollers 2 as shown in the diagrammatic view in Figure 1; in the state of the art, in principle there is only a cutting blade 3 per track between the direction-changing rollers 2.

As can be seen from Figures 2 to 4, a hot-stamping foil or generally a stamping foil, as is to be cut in accordance with the invention, comprises a carrier film 4 on which is arranged a decorative layer which is generally identified by 5. The decorative layer 5 is of different structures, depending on the respective area of use involved. For example, starting from the carrier film 4, the decorative layer 5 can include a release layer 6, for example a layer of wax which provides that the decorative layer is easy to release from the carrier film 4, a protective lacquer layer 7, a colour layer 8 which represents the actual decoration, and an adhesive layer 9, the adhesive layer 9 serving to suitably fix the decorative layer 5 of the hot-stamping foil on a substrate under the effect of heat and/or pressure. The actual decorative layer 8 is generally formed by at least one lacquer layer. It may however for example also comprise a plurality of lacquer layers, in which respect consideration is also to be given to the possibility of interfaces between two lacquer layers in the layer arrangement 8 being spatially structured, that is to say formed by diffraction or hologram structures. Particularly in such a case but also if the stamping foil involved is one which is to simulate a metal foil, a metal layer is also present within the layer arrangement 8; the metal layer can for example involve an aluminium layer produced by vacuum vapour deposition.

The structure of stamping foils, in particular hot-stamping foils, and the composition of their decorative layers is generally known. Here attention is directed for example to DE 44 23 291 A1.

As already mentioned in the opening part of this specification, the decorative layers are frequently brittle so that they flake or chip off if the attempt is made to cut the foil only by means of a blade 3. The parts of the decorative layer 5 which chip or flake off then form so-called cutting powder which can contaminate the foil produced and can give rise to problems in regard to processing of the foil.

Now, in accordance with the invention, to avoid that, the procedure involved is such that arranged upstream of the actual cutting blade 3 in the direction of movement (arrow 10 in Figure 1) is a laser 11 whose beam 12 produces in the decorative layer 5 of the foil 1 a removal track 13 in which - as can be clearly seen from Figure 2 - the decorative layer 5 is removed from the carrier film 4 so that the blade 3 now only acts on the carrier film 4 and cuts it apart, thereby preventing the generation of cutting powder comprising chipped-off or flaked-off particles of the decorative layer 5.

The individual steps in the cutting method according to the invention are described in greater detail with reference to Figure 2.

The top part of the view in Figure 2 indicates that a laser beam 12 whose outlines are indicated impinges in the direction of the arrow 14 on the decorative layer 5 of the foil 1. As a result, the decorative layer 5 is fused or vaporised and removed in the corresponding regions, if the level of intensity of the laser radiation is sufficiently high, thereby exposing the carrier film 4 in the region of the laser beam 12.

The width b of the removal track 13 exposed by the laser beam 12 in the decorative layer 5, as the middle of Figure 2 shows, is markedly greater than the thickness d of the blade 3. In general terms the width b of the removal track 13 should be between about 1 and 2 mm. As a result of the greater width b of the removal track 13 with respect to the thickness d of the blade 3, this ensures that the blade is satisfactorily guided in the removal track. The fluctuations in position between the laser and the blade track, which may possibly occur due to foil distortion, vibration and inaccuracies in the production machine, remain in that way without any influence on the quality of the cut.

As Figure 1 shows the blade 3 is arranged relatively closely downstream of the location 16 of action of the laser beam 12 on the decorative layer 5, in the direction of movement 10 of the foil 1, in which respect the spacing between the impingement point 16 of the laser beam

12 and the blade 3 can be for example about 50 mm. That fact also helps to compensate for any positional fluctuations or distortion of the foil 1 to be cut.

Then, as is shown in the bottom part of Figure 2, the blade 3 severs the carrier film 4 in the previously known manner in order in that way to separate the foil which is fed thereto (top of Figure 2) into two foil strips 1a and 1b (bottom of Figure 2), by means of a cut 17.

Figures 3 and 4 each show in the upper part thereof the laser beam intensity distribution transversely with respect to the direction of advance movement of the foil 1, which in the present case is perpendicular to the plane of the paper.

In Figure 3 the intensity curve 18 has comparatively steep rising and falling edges 19 and 20 respectively. In this case the intensity distribution involves a so-called rectangular or "top hat" profile. Accordingly that then also gives substantially straight and steep sides 21 for the removal track 13 in the decorative layer 5.

In comparison, as shown by the curve in the upper part of Figure 4, the laser radiation 12 involves a Gaussian intensity profile transversely with respect to the direction of movement of the foil 1. That then means that the sides 21′ of the removal track 13, as shown in the bottom part of Figure 4 and as also illustrated in Figure 2, have a lesser slope and in particular have a certain degree of rounding in the region of the side of the decorative layer, which is towards the laser beam. A Gaussian intensity profile in respect of the laser radiation 12 can also have the result that thrown-up portions of molten material are even to be observed at the edges of the removal track 13.

In regard to the lasers 11 which can be used for the method and the apparatus according to the invention, it is pointed out that CO_2-, Nd:YAG- and excimer lasers are industrially already used for cutting plastic materials. The possibilities of using high-power diode lasers are being investigated at the present time.

Operating parameters and areas of use of the laser beam sources for cutting plastic materials are set forth in the Table hereinafter:

Laser	Wavelength	Operating mode	Use
CO_2-laser	10.6 μm	cw, pulse	industry
Nd:YAG-laser	1.064 μm	cw, pulse	industry
Excimer laser	193, 248, 308 nm	pulse	industry
Diode laser	650 to 900 nm	cw, pulse	laboratory

Desirably however in particular Nd:YAG- and diode lasers are used for the invention because lasers of that kind on the one hand make it possible to achieve very high working speeds while on the other hand the radiation thereof is not absorbed or is absorbed only to a minor degree in the usually transparent carrier film, so that it is possible to avoid damaging the carrier film. Tests have shown that, with hot-stamping foils of conventional structure with polyester foils as the carrier film, when using Nd:YAG- or diode lasers, it is possible to achieve winding speeds of 70 m/min and more, in which respect only levels of laser power in the range of between 20 and 50 W are required for that purpose, more specifically in order in that way to produce a removal track 13 in the range of between 1 and 2 mm in width. In this respect, the laser radiation can be very rapidly laterally deflected by beam-deflecting components, for example acusto-optical modulators or galvanometer mirrors, in order in that way to permit positional regulation for the removal track 13. There is also the possibility of very rapidly adjusting the width b of the removal track 13 by focus-shifting components, for example adaptive optical systems. Finally, a variation in the speed of movement of the foil with respect to the laser beam, which would possibly result in a different removal track and which occurs in particular when starting up or slowing down the foil at the beginning and end of a cutting operation or when

cutting out poor-quality portions of foil, can be compensated by the laser power being appropriately altered, in which case with a higher speed of movement operation is implemented with a correspondingly higher level of power.